CROP ROTATION VS CONTINUOUS CROPPING YIELDS

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The need for the installation of sound conservation practices on farms in every section of the country is becoming more appreciated all the while. Considerable progress has been made along this line as a result of the efforts of Federal and State agencies but much remains to be done before conservation farming is as widely practiced as conditions warrant. One important means by which this program can be implemented is by the collection, analysis and presentation of important data bearing upon various conservation practices.

Much has been done to show the importance of crop rotation as a sound conservation measure and many farmers are now practicing it in varying degrees. However, much can be done by getting many of those farmers now practicing rotation to improve their present system and by introducing crop rotation to the tens of thousands of farmers over the country not now using it.

Realizing the need for a more universal use of suitable rotations on most of the farms throughout the country, an attempt has been made to collect, analyze and present important data showing the relative value of different types of rotations as compared with continuous culture. Unfortunately, however, there is a scarcity of data suitable for making appropriate comparisons.

For this study, yield data for the various crops were reduced to total digestible nutrients and the differences in yields resulting from the use of rotations over those of continuous culture were expressed in terms of corn equivalent. This basis of comparison should be fairly satisfactory for a livestock system of farming but it has its limitations when applied to other types.

For one thing the cost of producing a given amount of total digestible nutrients may vary appreciably with different crops. Even though oats or wheat may produce smaller yields per acre than corn, when measured in terms of total digestible nutrients, the difference in the cost of growing the small grain may be sufficiently in their favor to make their production more profitable than corn. Neither should the market value of the crops being considered be overlooked. There may be sufficient price differential between crops to justify the production of one over another, even though the higher priced one may be distinctly lower yielding than the other.

One crop may be favored more by local soil and climatic conditions than another. This is particularly true in those areas where available moisture is apt to be a decisive factor. It is often profitable to grow wheat or oats where it would not be for corn because there is not sufficient moisture available or else it is available during the wrong season for corn. The use of small grain crops in a rotation also permits a more economical use of labor than continuous corn culture. Small grains also have an added value in many places as a nurse crop or companion crop for clover, alfalfa and other close growing crops.

Since the object here is to show the effect of rotation over continuous culture, only those data were selected which permitted a direct comparison of the two systems. It is not claimed that all such data available have been used but it is believed that the majority of these have been included. The data are presented in the attached table.

A careful study of the data in the table brings out some interesting facts. One of the most conspicuous of these is this, that unless a rotation includes a legume or sod crop, such as timothy, the average annual yields in terms of total digestible nutrients based solely on the grain are not necessarily increased as a result of changing from continuous culture to a rotation. This is particularly the case when oats or wheat or both are introduced into a rotation with corn, or when either or all of these are introduced into a rotation with timothy, alfalfa, or other suitable hay crops.

For instance, in Indiana the average annual yield from continuous corn was 2,103 pounds of total digestible nutrients per acre when only the grain was considered, but when oats were introduced into a two-year rotation with corn the average of the total yield of the crops declined to 1,777 pounds. In Illinois the yield for continuous corn was 1,792 pounds of total digestible nutrients. When oats were introduced into a two-year rotation with corn the average annual yield on the plot dropped to an average of around 1,429 during the first 16 years of the experiment. During the last 36 years of the test the average annual yields for the two-year rotation of corn and oats were slightly larger than those for continuous corn in both the unfertilized and fertilized series. The yield of continuous corn in the unfertilized series was 1,133 pounds total digestible nutrients compared with 1,164 for the corn and oats rotation. In the fertilized series the yields were 1,864 for continuous corn and 2,014 for the corn and oats rotation.

The corn and oats rotation plot in Ohio out-yielded the continuous corn plot. However, the corn and oats rotation also included sweet clover as a green manure crop whereas the continuous corn plot did not, consequently the results are not directly comparable.

In practically every case the yields for continuous wheat were larger than those for continuous oats. Likewise the yields for a two-year rotation of corn and wheat were greater than those from the corresponding corn-oats rotation plots, but not as large as for the continuous corn plots.

The data in the corn equivalent section of the table are interesting in this connection. The addition of other crops to oats to form a rotation invariably resulted in the production of higher average annual yields of total digestible nutrients than oats grown continuously. Substantial increases resulted in every case, even where a rotation of only corn and oats was used. The increase was much more substantial, however, where legumes or timothy or both were added to the rotation. The results for soybeans were similar to those for oats in every case where they were grown for grain. In every instance, except three, the yields from continuous wheat were less than those from rotations including wheat. The three exceptions were in Ohio where in each case the rotation included soybeans as a grain crop. More important still, these data sho that without exception the average annual production of total digestible nutrients was less from rotations including grain crops than those from continuous hay crops. In short, when hay crops shared time with grain crops the average overal production was adversely affected. Corn, on the other hand, being intermediate between oats, wheat and soybeans on one hand and clover, alfalfa and timothy on the other showed a mixture of declines and increases for production in the rotation cycle when it shared time with other crops to form a rotation as compared with continuous corn.

Another point of interest is that the inclusion of soybeans as a seed crop in a rotation has a depressing effect on the overall yield during the rotation cycle. They consistently yield less than either corn or wheat and often less than oats. Soybeans, however, are not generally grown in the strictest sense as a grain crop.

One of the most important features brought out in the table is the effect of legumes, such as clovers and alfalfa, or sod crops, such as timothy, on average annual yields of crops either grown continuously or when included in a rotation. These results indicate that the longer the land is occupied by the sod crops the greater the total production of total digestible nutrients as a rule.

This is clearly demonstrated by the use of continuous timothy compared with its use in rotations in Missouri. Continuous timothy on both the unmanured and the manured plots produced larger yields than either continuous corn, oats or wheat. The introduction of these grain crops into the rotation at the expense of time previously allotted to timothy also resulted in lower average annual yields for the rotation cycle. This is substantiated by the minus signs before the yields in the hay column where yields are expressed in terms of corn equivalent.

The yield data in Missouri for those rotations where clover was used may be subject to question because the yields for continuous timothy were assumed to apply equally well to clover, which perhaps is not the case.

Some of the clover yields, particularly in Ohio, are low because of the large number of failures of this crop during the course of the experiment. This, however, is one of the hazarxs with which the farmer has to contend and the results should not be passed over because of that fact.

Another important fact brought out is that crop rotation alone is not sufficient to maintain high crop yields. The use of additional plant nutrients in the form f commercial fertilizer, manure, and limestone are essential if production is be maintained at a high level. For example, in Missouri the use of manure creased the yield of continuous corn 79 percent, continuous oats and wheat, 64 nd 82 percent, respectively, and continuous timothy 102 percent. The increases due to the use of manure in the three-, four- and six-year rotations were significant also. They were 91, 34 and 67 percent for the three-, four- and six-year rotations, respectively. The yields of the four-year rotation plots were doubtless influenced to some extent by the lime that blew in from the road. The increase in yields from the use of fertilizer in Virginia were 94 percent for continuous corn, 124 for continuous wheat, 80 for continuous clover and 98 for the four-year rotation of corn, wheat and two years of clover.

The use of manure in addition to commercial fertilizer resulted in further worth-while increases in yields. The increases resulting from the use of manure were 46 percent for continuous corn, 29 for continuous wheat, 55 for corn (soybean) wheat (soybean) rotation and 19 percent for the corn-wheat rotation.

It is also significant to note that the cropping systems which produce the greatest yields are those which experiments have shown to result in the smallest loss of soil and water. Results obtained at the several soil erosion experiment stations throughout the country show that soil and water losses are much lower on fields devoted to close growing or sod crops than those devoted to cultivated crops such as corn, or even to such close growing crops as oats and wheat.

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EFFECT OF CROP ROTATION, AS COMPARED WITH CONTINUOUS CULTURE, ON YIELDS - EXPRESSED IN TERMS OF AVERAGE ANNUAL YIELDS OF TOTAL DIGESTIBLE NUTRIENTS AND CORN EQUIVALENT PER ACRE

State	Soil: Area	Soil: Type	Average Annual Acre Yield of Total Digestible Nutrients for: Corn (Lbs.)	Oats (Lbs.)	Wheat (Lbs.)	Hay (Lbs.)	All (Lbs.)	Effect of Practicing Rotation vs. Continuous Cropping on Acre Yields Expressed in Corn Equivalent for: Corn (Bu.)	Oats (Bu.)	Wheat (Bu.)	Hay (Bu.)	Soil Treatment, Average Annual Application of: N (Lbs.)	P_2O_5 (Lbs.)	K_2O (Lbs.)	Manure Per Rotation (Tons)	Total Lime Applied (Tons)	Length of Rotation (Yrs.)	Crops Used and Sequence Followed in Rotation	Duration (Yrs.)	Source of Data
Alabama 1/		Cecil Sandy Loam	526				526						24	32				Corn, continuous	29	Bulletin 232
		" " "	823				823	6.6					24	32			1	Corn, Cowpeas, Vetch	29	" "
		" " "	575 2/				575 2/						24	32				Cotton, continuous	30	" "
		" " "	749 2/				749 2/	3.9 2/					24	32			1	Cotton and Vetch continuously	30	" "
		" " "	963 2/				963 2/	9.7 2/					24	32			2	Cotton, Vetch, Cowpeas 4/	30	" "
Indiana	Black and Clay	Miami, Crosby, Clyde, Brookston Silt	2,103				2,103											Corn, continuous	22	Circular 242
				1,117			1,117											Oats, continuous	22	" "
					1,323		1,323											Wheat, continuous	22	" "
	"	"	2,514	1,039			1,777	- 7.2	14.6								2	Corn, Oats	22	" "
	"	"	2,668		1,312	2,364	2,115	.3		17.6							3	Corn, Wheat, Clover	26	" "
	"	"	2,505(2)		1,364	2,163	2,134	.7		18.0							4	Corn (2), Wheat, Clover	26	" "
	"	"	2,808(2)	1,309 3/	1,713	2,261	2,180	1.7		19.0							5	Corn (2), Soybeans, Wheat, Clover	26	" "
	"	"	2,898(2)		1,660	3,519(3)	3,002	20.0 4/		37.2							6	Corn (2), Wheat, Alfalfa (3)	26	" "
	"	"	2,604	1,050			1,827	- 6.1 4/	15.7 4/								2	Corn, Oats (Sweetclover)	13	" "
	"	"	2,869	1,060		1,999	1,976	- 2.8	18.9								3	Corn, Oats, Clover	26	" "
	"	"	2,940	1,277 3/	1,685	2,247	2,037	- 1.5		15.8							4	Corn, Soybeans, Wheat, Clover	26	" "
	"	"	2,861		1,357	3,295	2,504	8.9		26.2							3	Corn, Wheat, Alfalfa	26	" "
	"	"	2,894		1,329	2,389	2,250	3.3		20.6							4	Corn, Wheat, Timothy, Clover	26	" "
	"	"	2,579	1,303 3/	1,668		1,850	- 5.6		11.7							3	Corn, Soybeans, Wheat (Sweetclover)	26	" "
	"	"	2,699		1,367	1,673	1,913	- 4.2		13.1							3	Corn, Wheat, Sweetclover	26	" "
Missouri		Putnam Silt Loam	835				835											Corn, continuous	50	Bulletin 458
		" " "	1,494				1,494								6			Corn, continuous	50	" "
		" " "		460			460											Oats, continuous	50	" "
		" " "		755			755								6			Oats, continuous	50	" "
		" " "			517		517											Wheat, continuous	50	" "
		" " "			943		943								6			Wheat, continuous	50	" "
		" " "				1,305	1,305											Timothy, continuous	50	" "
		" " "				2,630	2,630								6			Timothy, continuous	50	" "
		" " "	1,431		692	884	1,002	3.7		9.4	- 6.7						3	Corn, Wheat, Clover	50	" "
		" " "	2,117		1,259	2,374	1,917	9.4		21.6	-15.8				6		3	Corn, Wheat, Clover	50	" "
		" " "	1,652 5/	615 5/	1,083 5/	1,183 5/	1,133 5/	6.6	14.9	13.7	- 3.8						4	Corn, Oats, Wheat, Clover	50	" "
		" " "	2,031 5/	851 5/	1,078 5/	2,138 5/	1,524 5/	.7	17.0	12.9	-24.5				6		4	Corn, Oats, Wheat, Clover	50	" "
		" " "	1,711	680	793	1,227(3)	1,144	6.9	15.2	13.9	- 3.6						6	Corn, Oats, Wheat, Clover, Timothy (2)	50	" "
		" " "	2,293	730	1,415	2,351(3)	1,915	9.3	25.7	21.6	-38.0				6		6	Corn, Oats, Wheat, Clover, Timothy (2)	50	" "
North Carolina		Porter Loam	885				885					12	28	10				Corn, continuous	13	Bulletin 315
		" "	1,295				1,295					12	28	10	4			Corn, continuous	13	" "
		" "			371		371					12	28	10				Wheat, continuous	13	" "
		" "			477		477					12	28	10	4			Wheat, continuous	13	" "
		" "	1,449		346		898	.3		11.7		12	28	10			2	Corn (Soybeans), Wheat (Soybeans)	13	" "
		" "	2,000		782		1,391	2.1		20.3		12	28	10	4		2	Corn (Soybeans), Wheat (Soybeans)	13	" "
		" "	1,602		577	1,211	1,130	5.4		16.8		10	31	12			3	Corn (Soybeans), Wheat, Red Clover	13	" "
		" "	1,823		1,038	2,139	1,667	8.2		26.4		10	31	12	4		3	Corn (Soybeans), Wheat, Red Clover	13	" "
		" "	1,286		421		854	- .7		10.7		12	28	10			2	Corn, Wheat	13	" "
		" "	1,589		451		1,020	- 6.1		12.0		12	28	10	4		2	Corn, Wheat	13	" "
Virginia		Dunmore Silt Loam	759				759									?		Corn, continuous 6/	24	Bulletin 317
					436		436									?		Wheat, continuous 6/	24	" "
						1,133	1,133									?		Clover, continuous 6/	24	" "
			1,467		331	935(2)	911	3.4		10.5	- 4.9					?	4	Corn, Wheat, Clover (2) 6/	24	" "
			1,477				1,477					20	70	100		?		Corn, continuous	24	" "
					978		978					20	70	100		?		Wheat, continuous	24	" "
						2,040	2,040					20	70	100		?		Clover, continuous	24	" "
			2,538		1,064	1,819(2)	1,807	7.3		18.4	- 5.2	20	70	100		?	4	Corn, Wheat, Clover (2) 7/	24	" "
Ohio			1,219				1,219						32		2	?		Corn, continuous	15	Handbook of Experiments in Agronomy
				1,071			1,071						32		2	?		Oats, continuous (Sweetclover)	15	
					1,831		1,831						32		2	?		Wheat, continuous (Sweetclover)	15	
						724 3/	724 3/						32		2	?		Soybeans, continuous	15	
			3,308			315 13/	1,812	13.1					32		4	?	2	Corn, Red Clover	15	"
			3,412			396 14/	1,909	15.3					32		4	?	2	Corn, Sweetclover	15	"
			2,487			978 3/	1,733	11.4			22.4 3/		32		4	?	2	Corn, Soybeans	15	"
			2,997	1,146			2,072	18.9	22.2				32		4	?	2	Corn, Oats, (Sweetclover)	15	"
			2,889		1,625		2,257	23.0		9.4			32		4	?	2	Corn, Wheat (Sweetclover)	15	"
					1,379	1,112 3/	1,246			-13.0	11.6 3/		32		4	?	2	Soybeans, Wheat, (Sweetclover)	15	"
			2,993		1,911	2,013	2,072	18.9		5.3			32		6	?	3	Corn, Wheat, Red Clover	15	"
			3,254	1,249		2,019	2,174	21.2	24.5				32		6	?	3	Corn, Oats, Red Clover	15	"
			3,453		1,871	2,782	2,702	32.9		19.3			32		6	?	3	Corn, Wheat, Sweetclover	15	"
			3,484		1,921	2,800	2,735	33.6		20.0			32		6	?	3	Corn, Wheat, Alfalfa	15	"
			3,056		1,705	1,868	2,210	22.0		8.4			32		6	?	3	Corn, Wheat, Timothy	15	"
			1,184 3/		1,881	1,890	1,652	20.6		- 4.0			32		6	?	3	Soybeans, Wheat, Red Clover	15	"
			2,798	1,320	1,941	1,826	1,971	16.7	20.0	3.1			32		[illegible]	?	4	Corn, Oats, Wheat, Red Clover	15	"
			3,187	1,348	1,831	2,033	2,100	19.5	22.8	8.2			32		8	?	4	Corn, Oats, Wheat, Timothy	15	"
			2,756(2)		1,680	1,880	2,268	23.3		9.7			32		8	?	4	Corn, Corn, Wheat, Red Clover	15	"
			3,020	1,138 3/	1,540	1,639	1,834	13.6		0.0	24.6 3/		32		8	?	4	Corn, Soybeans, Wheat, Red Clover	15	"
			3,363	1,304	2,011	1,885	2,141	20.4	23.7	6.9			32		8	?	4	Corn, Oats, Red Clover, Wheat, (Sweetclover)	15	"
			2,952(2)	1,277	1,665		2,211	22.0	25.3	8.4			32		8	?	4	Corn, Oats (Sweetclover), Corn, Wheat (S.clover)	15	"
			3,539			2,208(3)	2,541	29.3					32		8	?	4	Corn, Alfalfa (3)	15	"
			3,164	1,277	1,951	2,037(2)	2,093	19.4	22.7	5.8			32		10	?	5	Corn, Oats, Wheat, Clover-Timothy, Timothy	15	"
			3,466		1,871	2,045(3)	[illegible]	23.9		10.3			32		[illegible]	?	5	Corn, Wheat, Clover-Timothy, Timothy (2)	15	"
			3,054(2)		1,555	2,126(2)	2,383	25.8		12.2			32		10	?	5	Corn(2) Wheat, Clover-Timothy, Timothy	15	"
			2,845(3)		1,660	1,906	2,591	30.4		16.9			32		10	?	5	Corn(3), Wheat, Clover	15	"
			3,706	1,439		3,453(3)	3,101	41.7	45.0				32		10	?	5	Corn, Oats, Alfalfa (3)	15	"
Illinois	Brown Silt Loam	Muscatine Silt Loam	1,792				1,792											Corn, continuous 8/	16	Bulletin 300 and The Morrow Plots
	"	"	1,851	1,007			1,429	- 8.0									2	Corn, Oats 8/	16	
	"	"	2,167	1,089		2,168	1,808	.4									3	Corn, Oats, Clover 8/	16	
	"	"	1,133				1,133											Corn, continuous 9/	36	
	"	"	1,548	780			1,164	.7									2	Corn, Oats 9/	36	"
	"	"	2,144	1,121		1,356	1,540	5.2									3	Corn, Oats, Clover 9/	36	"
	"	"	1,864				1,864						10/		12/	5.85		Corn, continuous 11/	36	"
	"	"	2,677	1,350			2,014	3.3					10/		12/	5.85	2	Corn, Oats 11/	36	"
	"	"	3,015	1,547		2,820	2,461	13.2					10/		12/	5.85	3	Corn, Oats, Clover 11/	36	"

1/ During a nine-year period the inclusion of legumes in a 3-year rotation of corn, cotton and oats produced 24.2 bu. corn and 397 lbs. seed cotton per acre more than a similar rotation without the legumes. 2/ Seed cotton. 3/ Soybeans. 4/ Used last 13 years only. 5/ Contaminated with lime dust from street. 6/ Not fertilized. 7/ Received 16 tons manure and 219 lbs. raw rock phosphate every four years. 8/ Started with virgin soil in 1888. 9/ Same plots as used in 8/ from 1904-1918 without treatment. 10/ From 1904 through 1918 steamed bone meal applied annually at rate of 200 lbs. per acre and rock phosphate at 600 lbs. per acre annually. Beginning in 1919 the rate of bone meal was reduced to 50 pounds and the rock phosphate to 200. 11/ Same as 9/ except for the fact these plots were fertilized as stated in 10/ 12/ Beginning in 1904 manure was applied at rate of two tons per acre annually until 1909. Since 1909 all applications were in direct proportion to the crops removed from the respective plots; that is, in amounts equal in weight to the air-dry weight of the crop removed. 13/ Eleven clover failures in 21 years. 14/ Nine sweetclover failures in 21 years.